USB-1408FS

Analog and Digital I/O

User's Guide

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Table of Contents

Preface
About this User's Guide 5
What you will learn from this user's guide 5
Conventions in this user's guide 5
Where to find more information 5

Chapter 1
Introducing the USB-1408FS 6
USB-1408FS block diagram 6

Chapter 2
Installing the USB-1408FS 7
What comes with your shipment? 7
Hardware 7
Software 7
Documentation 7
Unpacking 7
Installing the software 7
Installing the hardware 7
Calibrating the USB-1408FS 8

Chapter 3
Functional Details 9
Analog input acquisition modes 9
Software paced 9
Hardware paced 9
External components 10
USB connector 10
LED 10
Screw terminals 10
Signal connections 12
Analog input 12
Analog output 14
Digital I/O 14
Counter input 15
Trigger input 15
SYNC I/O 15
Ground 16
+2.5VREF output 16
Power output 16
Accuracy 16
Synchronized operations 18
Mechanical drawings 19

Chapter 4
Specifications 20
Analog input 20
Analog output 21
Digital I/O 22
External trigger 23
External clock input/output 23
Counter section 24
Non-volatile memory 24

Microcontroller 24
Power 25
General 25
Environmental 25
Mechanical 25
Screw terminal connector 26
Differential mode pinout 26
Single-ended mode pinout 27
Declaration of Conformity 28

About this User's Guide

What you will learn from this user's guide

This user's guide describes the Measurement Computing USB-1408FS data acquisition device and lists device specifications.

Conventions in this user's guide

For more information about …

Text presented in a box signifies additional information and helpful hints related to the subject matter you are reading.

Caution! Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

bold text — **Bold** text is used for the names of objects on a screen, such as buttons, text boxes, and check boxes.

italic text — *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase.

Where to find more information

Additional information about the USB-1408FS is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation by phone, fax, or email with specific questions.

- Knowledgebase: kb.mccdaq.com
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@mccdaq.com

Introducing the USB-1408FS

The USB-1408FS is a USB 2.0 full-speed analog input and digital I/O data acquisition device supported under popular Microsoft® Windows® operating systems. It is designed for USB 1.1 ports, and was tested for full compatibility with both USB 1.1 and USB 2.0 ports.

The USB-1408FS features eight analog inputs, two 12-bit analog outputs, 16 digital I/O connections, and one 32-bit external event counter.

The analog inputs are software configurable for either eight 13-bit single-ended inputs or four 14-bit differential inputs. The digital I/O lines are independently selectable as input or output in two 8-bit ports. The 32-bit counter can count TTL pulses. A SYNC (synchronization) I/O line allows you to pace the analog input acquisition of one USB module from the clock output of another.

The USB-1408FS is powered by the +5 volt USB supply from your computer. No external power is required.

USB-1408FS block diagram

USB-1408FS functions are illustrated in the block diagram shown here.

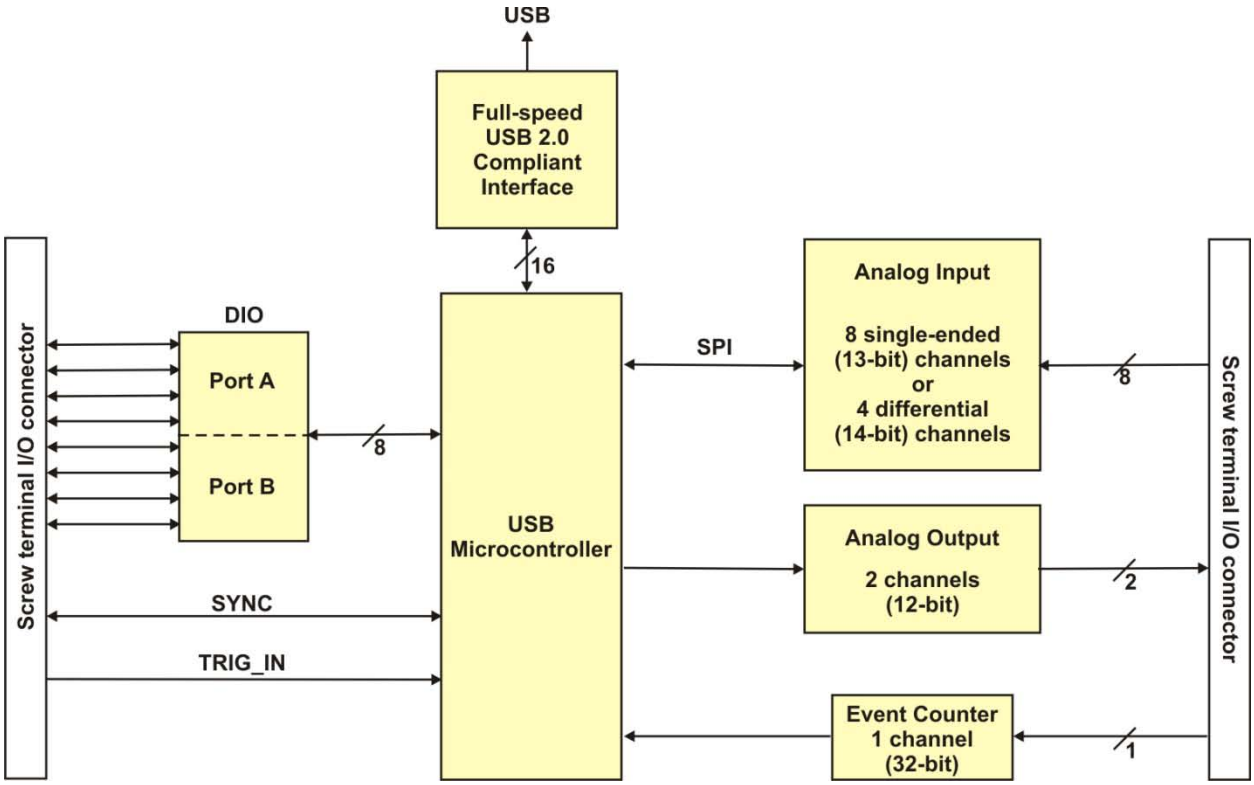


Figure 1. USB-1408FS functional block diagram

Installing the USB-1408FS

What comes with your shipment?

The following items are shipped with the USB-1408FS.

Hardware

- USB-1408FS
- USB cable

Software

- MCC DAQ CD

Documentation

In addition to this hardware user's guide, you should also receive the *Quick Start Guide*. This booklet provides an overview of the MCC DAQ software you received with the device, and includes information about installing the software. Please read this booklet completely before installing any software or hardware.

Unpacking

As with any electronic device, take care while handling to avoid damage from static electricity. Before removing the USB-1408FS from its packaging, ground yourself using a wrist strap or touch either the computer chassis or other grounded object to eliminate any stored static charge.

If the device is damaged, notify Measurement Computing Corporation immediately by phone, fax, or email.

- Knowledgebase: kb.mccdaq.com
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@mccdaq.com

For international customers, contact your local distributor. Refer to the International Distributors section on our web site at www.mccdaq.com/International.

Installing the software

Refer to the *Quick Start Guide* for instructions on installing the software on the MCC DAQ CD. This booklet is available in PDF at www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf.

Installing the hardware

Be sure you are using the latest system software

Before installing the device, run Windows Update to update your operating system with the latest HID and USB drivers.

To connect the USB-1408FS to your system, connect the USB cable to a USB port on your computer or to an external USB hub that is connected to your computer. The USB cable provides power and communication to the USB-1408FS.

The USB-1408FS installs as a composite device with separate devices attached. When you connect the USB-1408FS for the first time, a **Found New Hardware** dialog opens as each device interface is detected. This is normal. After the device is installed its LED will blink and then remain on. This indicates that communication is established between the USB-1408FS and your computer.

If the LED turns off

If communication is lost between the device and the computer, the device LED turns off. Disconnect the USB cable from the computer and then reconnect it. This should restore communication, and the LED should turn on.

Allow the USB-1408FS to operate for at least 30 minutes before using the device. This warm up time is required to achieve the specified rated accuracy of measurements.

Calibrating the USB-1408FS

The USB-1408FS is shipped fully calibrated. Calibration coefficients are stored in EEPROM. Return the device to Measurement Computing Corporation when calibration is required. The normal calibration interval is once per year.

Functional Details

Analog input acquisition modes

The USB-1408FS can acquire analog input data in either software-paced or hardware-paced mode.

Software paced

The USB-1408FS acquires data one analog sample at a time using software-paced mode. You initiate the A/D conversion by calling a software command. The analog value is converted to digital and returned to the computer. You can repeat this procedure until you have the total number of samples that you want.

The USB-1408FS can attain throughput rates up to 250 S/s using a software loop. This rate is system-dependent.

Hardware paced

The USB-1408FS can acquire data from up to eight channels in hardware-paced mode. The analog data is acquired and converted to digital values until you stop the scan. Data is transferred in blocks of 31 samples from the USB-1408FS to the memory buffer on your computer.

The A/D converter is paced by either an internal or external clock source.

The maximum sample rate is an aggregate rate. The total sample rate for all channels cannot exceed 48 kS/s. The following table lists the sample rate when scanning from one to eight channels.

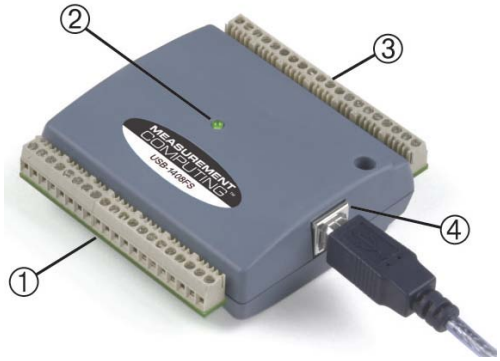
Maximum per channel sample rate

# channels scanned	Sample rate (kS/s)
1	48
2	24
3	16
4	12
5	9.60
6	8
7	6.85
8	6

You start a hardware-paced scan with a software command. Optionally, hardware-paced scans can be delayed by an external hardware trigger event.

External components

The external components – screw terminal banks, LED, and USB connector –are shown in Figure 2.



1	Screw terminal pins 21 to 40	3	Screw terminal pins 1 to 20
2	LED	4	USB connector

Figure 2. External components

USB connector

The USB connector provides +5V power and communication. No external power supply is required.

LED

The LED indicates the communication status; it cannot be disabled. LED states are listed in the table below.

LED behavior

LED Illumination	Indication
Steady green	The USB-1408FS is connected to a computer or external USB hub.
Blinks continuously	Data is being transferred.

Screw terminals

The screw terminals provide the following connections:

- Eight analog input connections (**CH0 IN** to **CH7 IN**)
- Two analog output connections (**D/A OUT 0** to **D/A OUT 1**)
- 16 digital I/O connections (**PortA0** to **Port A7**, and **Port B0** to **Port B7**)
- One external trigger input (**TRIG_IN**)
- One SYNC I/O for external clocking and multi-unit synchronization (**SYNC**)
- One external event counter input (**CTR**)
- One voltage output (**2.5VREF**)
- One power output (**PC+5 V**)
- Five analog ground connections (**AGND**) and four ground connections (**GND**)

Use 16 AWG to 30 AWG wire when making connections to the screw terminals. The single-ended mode pinout is shown in Figure 3.

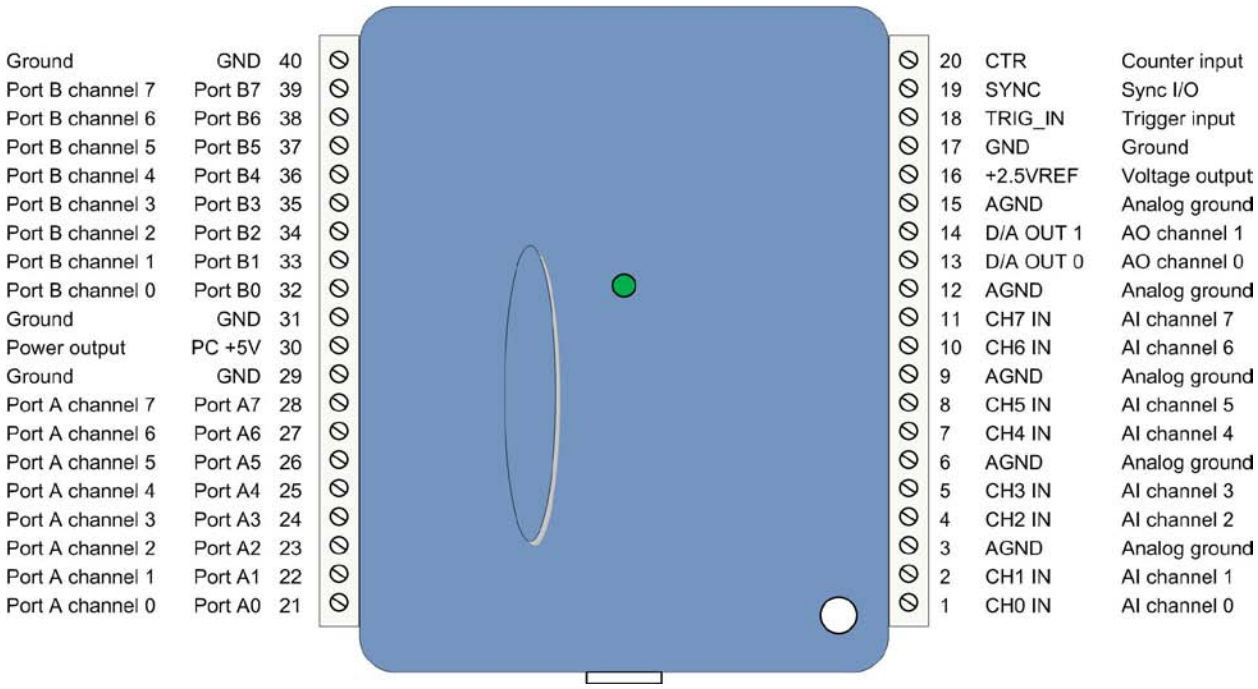

Ground GND 40
Port B channel 7 Port B7 39
Port B channel 6 Port B6 38
Port B channel 5 Port B5 37
Port B channel 4 Port B4 36
Port B channel 3 Port B3 35
Port B channel 2 Port B2 34
Port B channel 1 Port B1 33
Port B channel 0 Port B0 32
Ground GND 31
Power output PC +5V 30
Ground GND 29
Port A channel 7 Port A7 28
Port A channel 6 Port A6 27
Port A channel 5 Port A5 26
Port A channel 4 Port A4 25
Port A channel 3 Port A3 24
Port A channel 2 Port A2 23
Port A channel 1 Port A1 22
Port A channel 0 Port A0 21
20 CTR Counter input
19 SYNC Sync I/O
18 TRIG_IN Trigger input
17 GND Ground
16 +2.5VREF Voltage output
15 AGND Analog ground
14 D/A OUT 1 AO channel 1
13 D/A OUT 0 AO channel 0
12 AGND Analog ground
11 CH7 IN AI channel 7
10 CH6 IN AI channel 6
9 AGND Analog ground
8 CH5 IN AI channel 5
7 CH4 IN AI channel 4
6 AGND Analog ground
5 CH3 IN AI channel 3
4 CH2 IN AI channel 2
3 AGND Analog ground
2 CH1 IN AI channel 1
1 CH0 IN AI channel 0

Figure 3. Single-ended mode pinout

The differential mode pinout is shown in Figure 4.

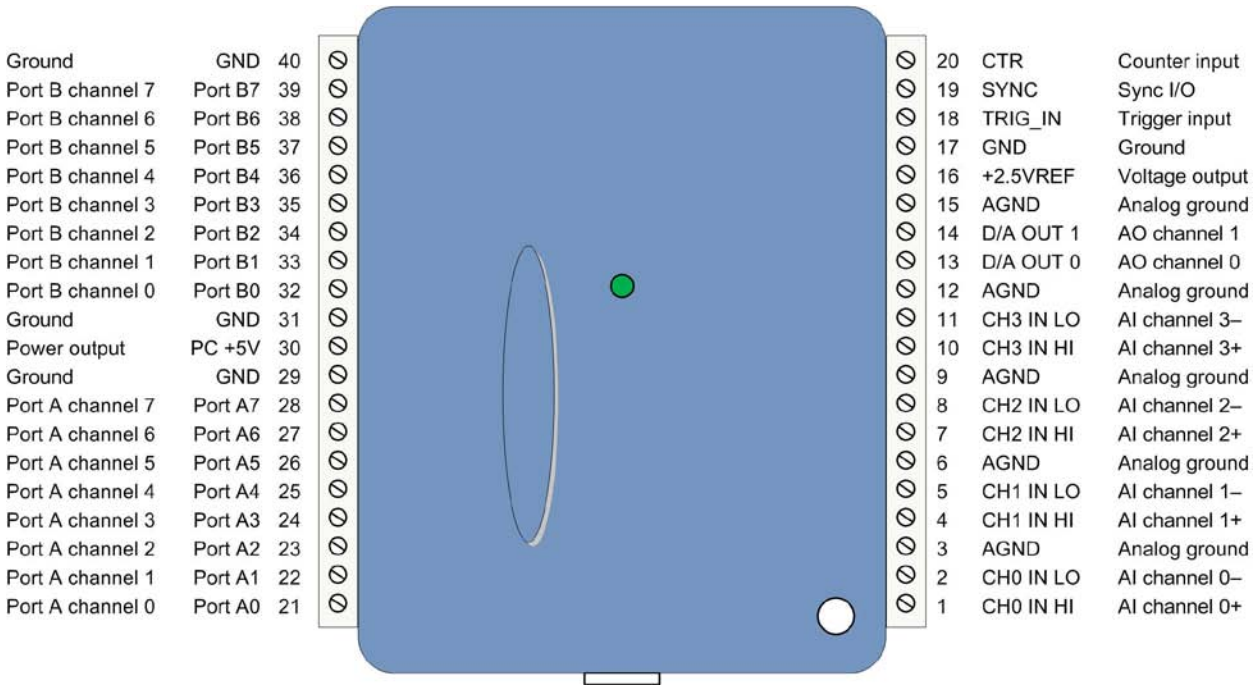

Ground GND 40
Port B channel 7 Port B7 39
Port B channel 6 Port B6 38
Port B channel 5 Port B5 37
Port B channel 4 Port B4 36
Port B channel 3 Port B3 35
Port B channel 2 Port B2 34
Port B channel 1 Port B1 33
Port B channel 0 Port B0 32
Ground GND 31
Power output PC +5V 30
Ground GND 29
Port A channel 7 Port A7 28
Port A channel 6 Port A6 27
Port A channel 5 Port A5 26
Port A channel 4 Port A4 25
Port A channel 3 Port A3 24
Port A channel 2 Port A2 23
Port A channel 1 Port A1 22
Port A channel 0 Port A0 21
20 CTR Counter input
19 SYNC Sync I/O
18 TRIG_IN Trigger input
17 GND Ground
16 +2.5VREF Voltage output
15 AGND Analog ground
14 D/A OUT 1 AO channel 1
13 D/A OUT 0 AO channel 0
12 AGND Analog ground
11 CH3 IN LO AI channel 3–
10 CH3 IN HI AI channel 3+
9 AGND Analog ground
8 CH2 IN LO AI channel 2–
7 CH2 IN HI AI channel 2+
6 AGND Analog ground
5 CH1 IN LO AI channel 1–
4 CH1 IN HI AI channel 1+
3 AGND Analog ground
2 CH0 IN LO AI channel 0–
1 CH0 IN HI AI channel 0+

Figure 4. Differential mode pinout

Signal connections

Analog input

You can connect up to eight analog input connections to the screw terminal containing pins 1 to 20 (**CH0 IN** through **CH7 IN**.)

You can configure the analog input channels as eight single-ended channels or four differential channels. When configured for differential mode, each analog input has 14-bit resolution. When configured for single-ended mode, each analog input has 13-bit resolution, due to restrictions imposed by the A/D converter.

Single-ended configuration

When all of the analog input channels are configured for single-ended input mode, eight analog channels are available. The input signal is referenced to signal ground (**GND**), and delivered through two wires:

- Connect the wire carrying the signal to be measured to **CH# IN**.
- Connect the second wire to **AGND**.

The input range for single-ended mode is ±10 V.

Single-ended measurements using differential channels

To perform a single-ended measurement using differential channels, connect the signal to the "**CH# IN HI**" input, and ground the associated **CH# IN LO** input.

Differential configuration

When all of the analog input channels are configured for differential input mode, four analog channels are available. In differential mode, the input signal is measured with respect to the low input.

The input signal is delivered through three wires:

- Connect the wire carrying the signal to be measured to **CH# IN HI**
- Connect the wire carrying the reference signal to **CH# IN LO**
- Connect the third wire to **GND**.

A low-noise precision programmable gain amplifier (PGA) is available on differential channels to provide gains of up to 20 and a dynamic range of up to 14-bits. Differential mode input voltage ranges are ±20 V, ±10 V, ±5 V, ±4 V, ±2.5 V, ±2.0 V, ±1.25 V, and ±1.0 V.

In differential mode, the following two requirements must be met for linear operation:

- Any analog input must remain in the −10V to +20V range with respect to ground at all times.
- The maximum differential voltage on any analog input pair must remain within the selected voltage range.

The input [*common-mode voltage* + *signal*] of the differential channel must be in the −10 V to +20 V range in order to yield a useful result. For example, you input a 4 V pp sine wave to CHHI, and apply the same sine wave 180° out of phase to CHLO. The common mode voltage is 0 V. The differential input voltage swings from 4 V− (−4 V) = 8 V to (−4 V) − 4 V = −8V. Both inputs satisfy the −10 V to +20 V input range requirement, and the differential voltage is suited for the ±10 V input range (see Figure 5).

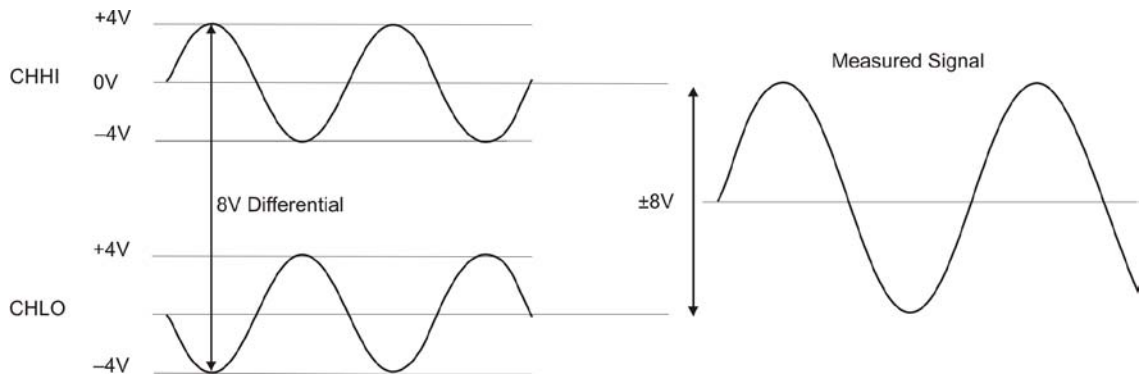


Figure 5. Differential voltage example: common mode voltage of 0 V

If you increase the common mode voltage to 11 V, the differential remains at ±8 V. Although the [*common-mode voltage + signal*] on each input now has a range of +7 V to +15 V, both inputs still satisfy the −10 V to +20 V input requirement (see Figure 6).

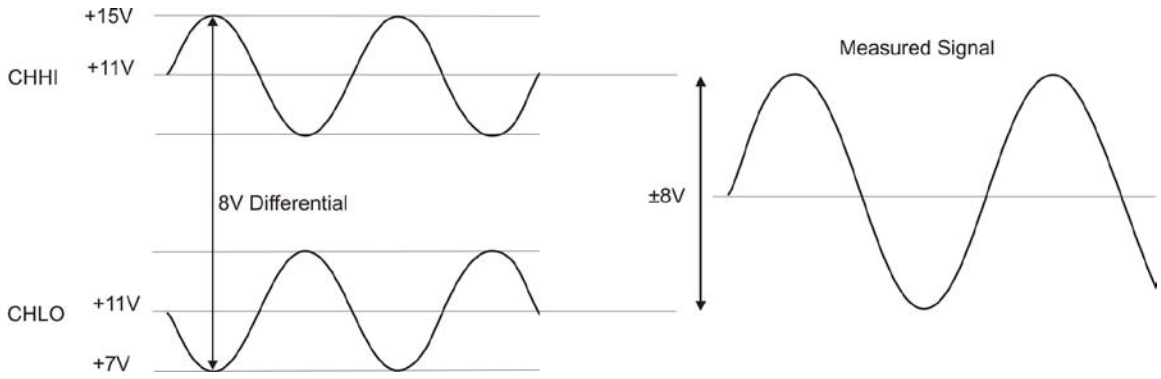


Figure 6. Differential voltage example: common mode voltage of 11 V

If you decrease the common-mode voltage to −7 V, the differential stays at ±8 V. However, the solution now violates the input range condition of −10 V to +20 V. The voltage on each analog input now swings from −3V to −11V. Voltages between −10 V and −3 V are resolved, but those below -10 V are clipped (see Figure 7).

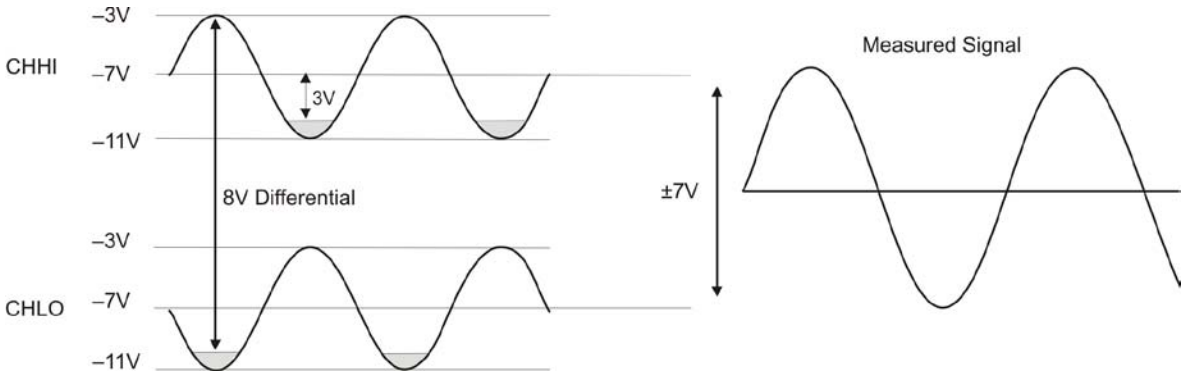


Figure 7. Differential voltage example: common mode voltage of -7 V

Since the analog inputs are restricted to a −10 V to +20 V signal swing with respect to ground, all ranges *except* ±20V can realize a linear output for any differential signal with zero common mode voltage and full scale signal inputs. The ±20 V range is the exception. You cannot put −20 V on CHHI and 0 V on CHLO since this violates the input range criteria. The following table shows some possible inputs and the expected results.

Sample inputs and differential results

CHHI	CHLO	Result
−20 V	0 V	Invalid
−15 V	+5 V	Invalid
−10 V	0 V	−10 V
−10 V	+10 V	−20 V
0 V	+10 V	−10 V
0 V	+20 V	−20 V
+10 V	−10 V	+20 V
+10 V	0 V	+10 V
+15 V	−5 V	+20 V
+20 V	0	+20 V

For more information on analog signal connections

For more information on single-ended and differential inputs, refer to the *Guide to Signal Connections* (this document is available on our web site at www.mccdaq.com/signals/signals.pdf)

Channel gain queue

The channel gain queue feature allows you to set up a scan sequence with a unique per-channel gain setting and channel sequence. The gain settings are stored in a channel-gain queue list that is written to local memory on the device.

The channel-gain queue list can contain up to 16 elements in any order. An example of a four-element list is shown in the table below.

Sample channel gain queue list

Element	Channel	Range
0	CH0	BIP10V
1	CH3	BIP5V
2	CH1	BIP10V
3	CH2	BIP1V

When a scan begins with the gain queue enabled, the USB-1408FS reads the first element, sets the appropriate channel number and range, and then acquires a sample. The properties of the next element are then retrieved, and another sample is acquired. This sequence continues until all elements in the gain queue have been selected. When the end of the channel list is detected, the sequence returns to the first element in the list. This sequence repeats until the specified number of samples is acquired.

Carefully match the gain to the expected voltage range on the associated channel or an over range condition may occur. Although this condition does not damage the device, it does produce a useless full-scale reading, and can introduce a long recovery time due to saturation of the input channel.

Analog output

You can connect up to two analog output connections to **D/A OUT 0** and **D/A OUT 1**. Each channel can be paced individually at rates up to 10,000 updates per second. Both channels can be paced simultaneously using the same time base at 5,000 updates per channel. The 0 V to 4.096 V output range provides a convenient 1 mV per LSB when setting the output voltage levels.

Digital I/O

The device has 16 digital bits configured as two 8-bit ports (Port A and Port B). You can connect up to eight digital I/O lines to each port (terminals **Port A0** to **Port A7** and **Port B0** to **Port B7**). Each port is configurable as either input or output.

When configured for input, you can use the digital I/O terminals to detect the state of any TTL level input. Refer to the schematic shown in Figure 8. If the switch is set to the +5 V input, Port A0 reads *TRUE* (1). If you move the switch to GND, Port A0 reads *FALSE*.

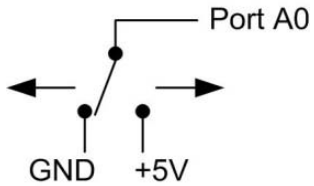


Figure 8. Schematic showing switch detection by digital channel Port A0

Pull-up/down configuration

Later hardware revisions are designed with user-configurable internal jumpers to configure the digital bits for pull-up (default) or pull-down. If the p/n of your board is 195920B, the default configuration is pull-up. To configure for pull-down, the board must be modified at the factory. If the p/n of your board is 193331x, where x is any letter, your board has the user-configurable internal jumpers. The hardware revision is listed with the part number on the bottom of the device, for example p/n 193331D.

If your board has user-configurable jumpers, complete the following steps to set the pull-up/down configuration:

1. Unplug the device from the computer.
2. Turn the device over and rest the top of the housing on a flat, stable surface.

Caution! The discharge of static electricity can damage some electronic components. Before removing the USB-1408FS from its housing, ground yourself using a wrist strap or touch the computer chassis or other grounded object to eliminate any stored static charge.

3. Remove the three screws from the bottom of the device using a #1 Philips head screwdriver.
4. Hold both the top and bottom sections together, turn the device over and rest it on the surface, then carefully remove the top section of the case to expose the circuit board.

   The user-configurable jumpers are labeled **DIO A** and **DIO B**. Figure 9 shows the location of the each jumper on the circuit board.

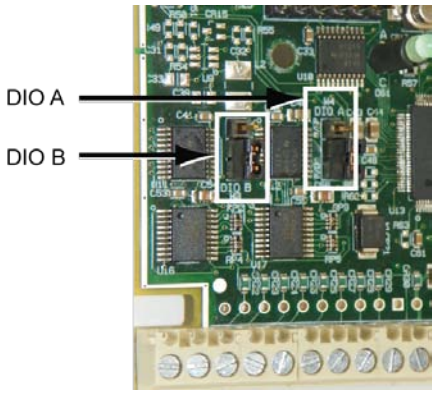


Figure 9. Pull-up/down jumper locations

5. Configure each jumper for pull-up or pull-down, as shown in Figure 10. Use the jumper labeled **DIO A** to configure Port A, and **DIO B** to configure Port B.

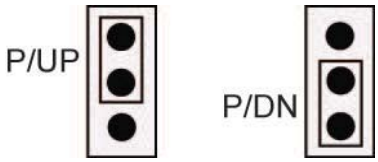


Figure 10. Pull-up/down jumper configuration

6. Replace the top section of the housing, and fasten it to the bottom section with the three screws.

Counter input

The **CTR** terminal is a 32-bit event counter that can accept frequency inputs up to 1 MHz. The internal counter increments when the TTL levels transition from low to high.

Trigger input

The **TRIG_IN** terminal is an external digital trigger input that you can configure for either rising or falling edge.

SYNC I/O

The **SYNC** terminal is a bidirectional I/O signal that can be configured as an input (default) or an output.

- Configure as an external clock input to externally source the A/D conversions. The **SYNC** terminal supports TTL-level input signals of up to 50 kHz.
- Configure as an output to synchronize with a second USB-1408FS and acquire data from 16 channels.

Refer to Synchronized operations on page 18 for more information.

Ground

The analog ground (**AGND**) terminals provide a common ground for all analog channels. The ground (**GND**) connections provide a common ground for the digital, trigger, counter, sync and power terminals.

+2.5VREF output

The **+2.5VREF** connection is an output terminal that supplies 2.5 volts. You can use this pin as the voltage source for another analog channel. For example, to configure the **+2.5VREF** pin as the voltage source for channel 0 in SE mode, connect **+2.5VREF** to **CH0 IN**. In differential mode, connect **+2.5VREF** to **CH0 IN HI**, and connect **CH# IN LO** to **AGND**.

Power output

The **PC +5V** terminal is a 5 volt output that is supplied by the computer. You can use this terminal to supply power to external devices or circuitry.

Caution! The +5 V terminal is an output. Do not connect to an external power supply or you may damage the USB-1408FS and possibly the computer.

The maximum total output current that can be drawn from all USB-1408FS connections (power, analog and digital outputs) is 420 mA. This maximum applies to most personal computers and self-powered USB hubs. Bus-powered hubs and notebook computers may limit the maximum available output current to 100 mA.

Just connecting the USB-1408FS to your computer draws 80 mA of current from the USB +5 V supply. Once you start running applications with the USB-1408FS, each DIO bit can draw up to 2.5 mA, and each analog output can draw 15 mA. The maximum amount of +5 V current available for experimental use, over and above that required by the USB-1408FS, is the difference between the *total current requirement* of the USB (based on the application), and the *allowed current draw* of the PC platform (500 mA for desktop PCs and self-powered hubs, or 100 mA for bus-powered hubs and notebook computers). With all outputs at their maximum output current, you can calculate the total current requirement of the USB-1408FS USB +5 V supply as follows:

(USB-1408FS @ 80 mA) + (16 DIO @ 2.5 mA ea) + (2 AO @ 15 mA ea) = 150 mA

For an application running on a PC or powered hub, the maximum available excess current is 500 mA − 150 mA = 350 mA. This number is the total maximum available current at the PC +5 V screw terminals. Measurement Computing highly recommends that you figure in a safety factor of 20% below this maximum current loading for your applications. A conservative, safe user maximum in this case would be 280 mA.

Since laptop computers typically allow up to 100 mA, the USB-1408FS in a fully-loaded configuration may be above that allowed by the computer. In this case, you must determine the per-pin loading in the application to ensure that the maximum loading criteria is met. The per-pin loading is calculated by simply dividing the +5 V by the load impedance of the pin in question.

Accuracy

The overall accuracy of any instrument is limited by the error components within the system. Resolution is often used incorrectly used to quantify the performance of a measurement product. While "14-bits" or "1 part in 16383" does indicate what can be resolved, it provides little insight into the quality of an absolute measurement. Accuracy specifications describe the actual measurement achievable with a USB-1408FS

There are three types of errors which affect the accuracy of a measurement system:

- offset
- gain
- nonlinearity

The primary error sources in the USB-1408FS are offset and gain. Nonlinearity is small in the USB-1408FS, and is not significant as an error source with respect to offset and gain.

Figure 11 shows an example of an ideal, error-free, USB-1408FS transfer function. The typical calibrated accuracy of the USB-1408FS is range-dependent, as explained in the "Specifications" chapter on page 20. We use a ±10 V range here as an example of what you can expect when performing a measurement in this range.

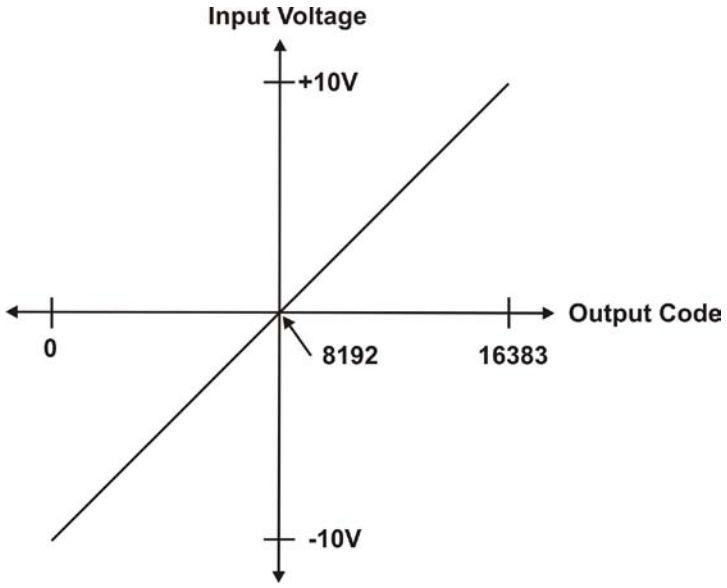


Figure 11. Ideal ADC transfer function

The offset error is measured at mid-scale. Ideally, a zero volt input should produce an output code of 8192. Any deviation from this is an offset error.

Figure 12 shows an example of a USB-1408FS transfer function with a ±2.44 mV offset error. Offset error affects all codes equally by shifting the entire transfer function up or down along the input voltage axis.

The accuracy plots in Figure 12 are drawn for clarity and are not drawn to scale.

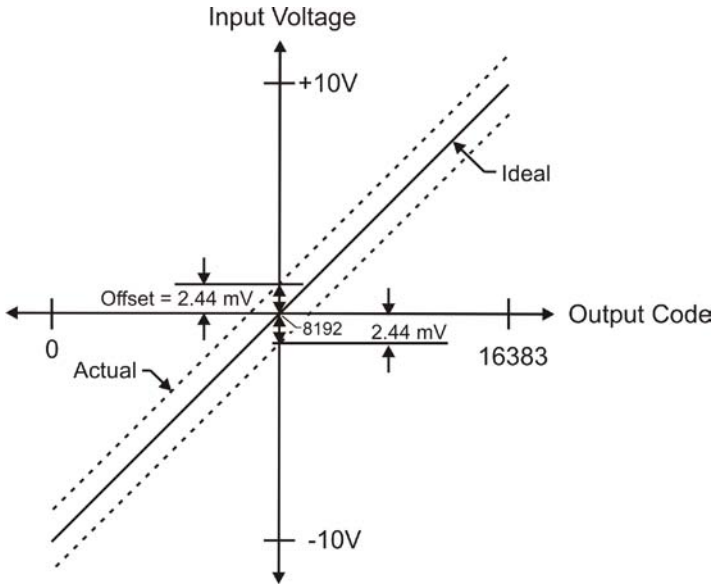


Figure 12. ADC transfer function with offset error

Gain error is a change in the slope of the transfer function from the ideal, and is typically expressed as a percentage of full-scale. Figure 13 shows the USB-1408FS transfer function with gain error. Gain error is easily converted to voltage by multiplying the full-scale (**FS**) input by the error.

The accuracy plots in Figure 13 are drawn for clarity and are not drawn to scale.

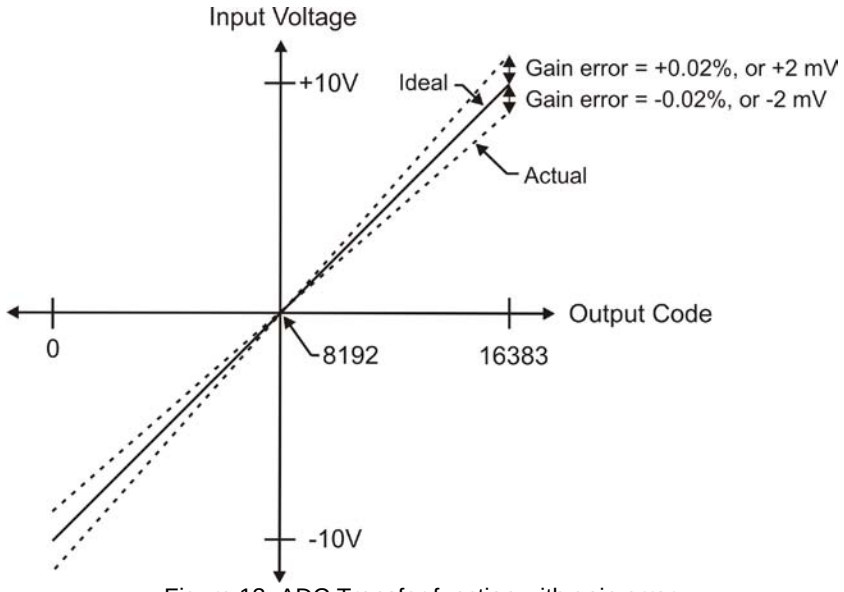


Figure 13. ADC Transfer function with gain error

Figure 13 shows an example of a USB-1408FS transfer function with a calibrated gain error of ±0.02%, or ±2 mV. This means that at full scale, neglecting the effect of offset for the moment, the measurement would be within 2 mV of the actual value. Note that gain error is expressed as a ratio. Values near ±FS are more affected from an absolute voltage standpoint than are values near mid-scale, which see little or no voltage error.

Combining these two error sources in Figure 14, we have a plot of the error band of the USB-1408FS for the ±10 V range. This is a graphical version of the typical accuracy specification of the product.

The accuracy plots in Figure 14 are drawn for clarity and are not drawn to scale

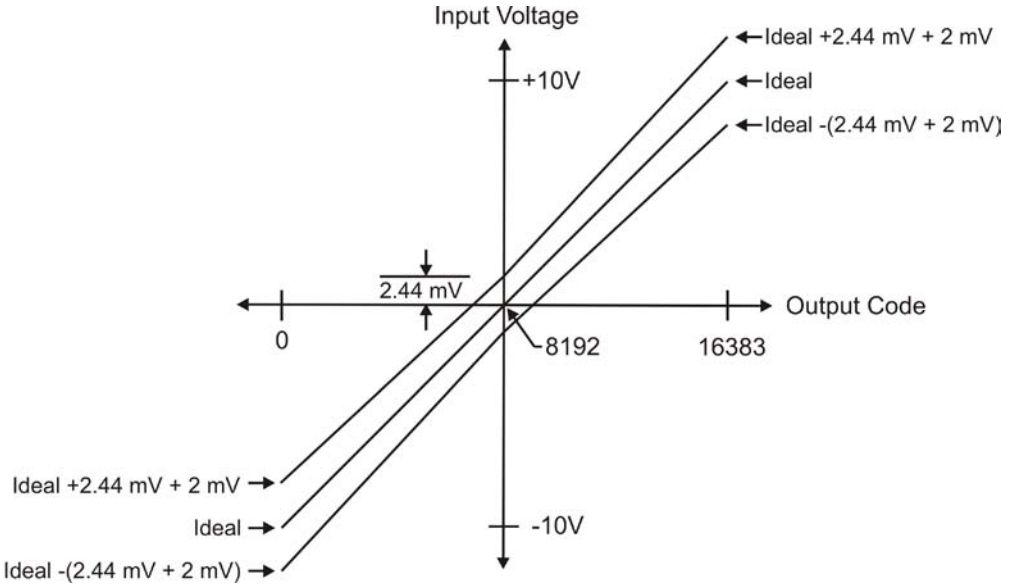
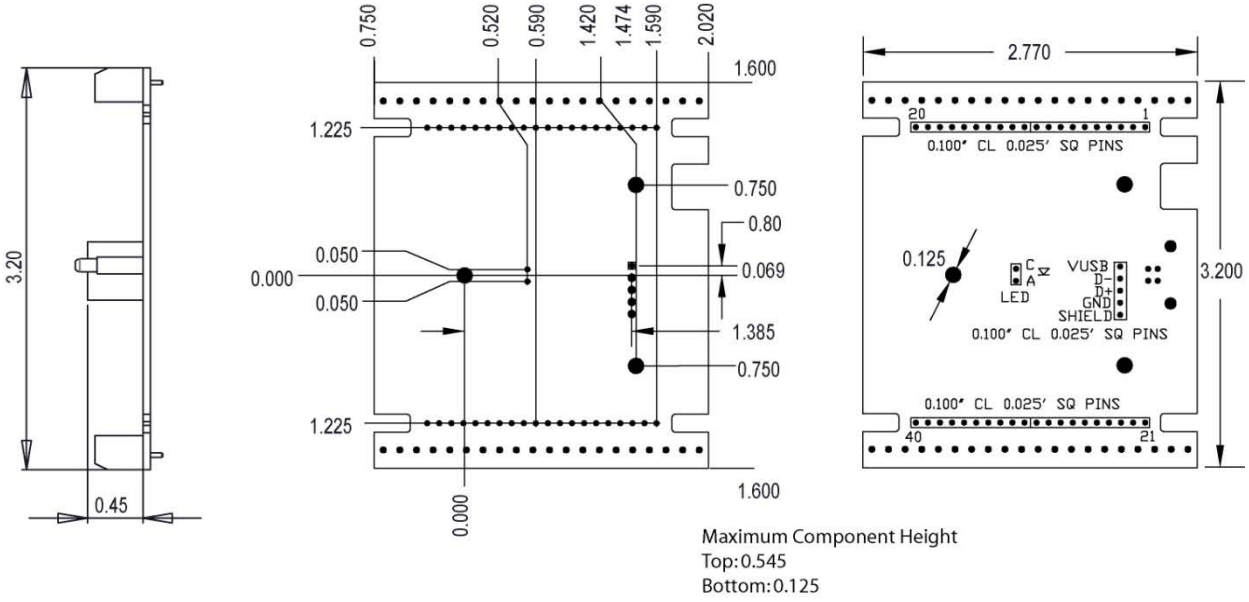


Figure 14. Error band plot

Synchronized operations

You can run up to two USB-1408FS devices on most computers. You can connect the SYNC pin of two devices together in a master/slave configuration and acquire data from the analog inputs of both devices using one clock. When the SYNC pin is configured as an output, the internal A/D pacer clock signal is sent to the screw terminal. You can output the clock to the SYNC pin of a second device that is configured for A/D pacer input.

Mechanical drawings



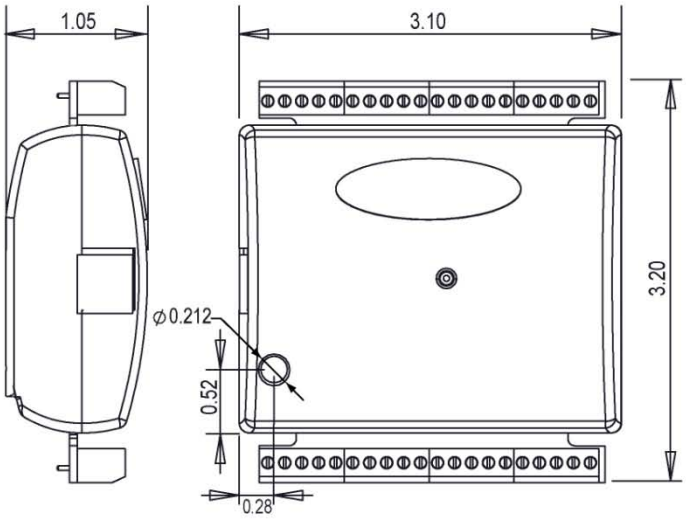


Figure 15. Circuit board (top) and enclosure dimensions

Specifications

All specifications are subject to change without notice.
Typical for 25°C unless otherwise specified.
Specifications in *italic text* are guaranteed by design.

Analog input

Table 1. Analog input specifications

Parameter	Conditions	Specification
A/D converter type		Successive approximation type
Input voltage range for linear operation, single-ended mode	CHx to GND	±10 V max
Input common-mode voltage range for linear operation, differential mode	CHx to GND	–10 V min, +20 V max
Absolute maximum input voltage	*CHx to GND*	*±28 V max*
Input impedance		*122 kΩ*
Input current (Note 1)	V_{in} = +10 V	70 µA typ
	V_{in} = 0 V	–12 µA typ
	V_{in} = –10 V	–94 µA typ
Number of channels	Software-selectable	8 single-ended / 4 differential
Input ranges, single-ended mode		±10 V, G=2
Input ranges, differential mode		±20 V, G=1 ±10 V, G=2 ±5 V, G=4 ±4 V, G=5 ±2.5 V, G=8 ±2.0 V, G=10 ±1.25 V, G=16 ±1.0 V, G=20 Software selectable
Throughput (Note 2)	Software paced	250 S/s typ, PC-dependent
	Hardware paced	48 kS/s
Channel gain queue	Up to 16 elements	Software configurable channel, range, and gain
Resolution (Note 3)	Differential	14-bits, no missing codes
	Single-ended	13-bits
Integral linearity error		±2 LSB typ
Differential linearity error		±0.5 LSB typ
Absolute accuracy long term drift (Note 4)	±20 V range	±3LSB typ (Δt = 1000 hr)
	±4 V range	±6LSB typ (Δt = 1000 hr)
	±1 V range	±8LSB typ (Δt = 1000 hr)
2.5VREF accuracy (pin 16)		±36.25 mV max
2.5VREF output current (pin 16)	Source	5 mA max.
	Sink	20 µA min, 100 µA typ
Trigger source	Software-selectable	External digital: TRIG_IN

Note 1: Input current is a function of applied voltage on the analog input channels. For a given input voltage, V_{in}, the input leakage is approximately equal to (8.181*V_{in} – 12) µA.

Note 2: Maximum throughput scanning to PC memory is machine dependent.

Note 3: The ADS7871 converter only returns 13-bits (0 to 8192 codes) in single-ended mode.

Note 4: Extrapolating the long term drift accuracy specifications will provide the approximate long term drift of the USB-1408FS intermediate input ranges.

Table 2. Accuracy, differential mode

Range	Absolute Accuracy 25 °C (±mV)	Absolute Accuracy 0 °C to 50 °C (±mV)
±20 V	10.98	49.08
±10 V	7.32	33.42
±5 V	3.66	20.76
±4 V	2.92	19.02
±2.5 V	1.83	14.97
±2 V	1.70	14.29
±1.25 V	1.21	12.18
±1 V	1.09	11.63

Table 3. Accuracy, single-ended mode

Range	Absolute Accuracy 25 °C (±mV)	Absolute Accuracy 0 °C to 50 °C (±mV)
±10 V	10.98	49.08

Table 4. Noise performance, differential mode

Range	Typical counts	Least significant bit$_{\text{root mean square}}$ (LSB_{rms})
±20 V	8	1.21
±10 V	8	1.21
±5 V	9	1.36
±4 V	10	1.51
±2.5 V	12	1.81
±2 V	14	2.12
±1.25 V	18	2.72
±1 V	22	3.33

Table 5. Noise performance, single-ended mode

Range	Typical Counts	LSB_{rms}
±10 V	8.0	1.21

Analog output

Table 6. Analog output specifications

Parameter	Conditions	Specification
Resolution		12-bits, 1 in 4096
Output range		*0 V to 4.096 V, 1 mV per LSB*
Number of channels		2
Throughput (Note 5)	Software paced	250 S/s single channel typical, PC-dependent
	Single channel, continuous scan	10 kS/s
	Dual channel, continuous scan, simultaneous update	5 kS/s
Power on and reset voltage		0V, ±20 mV typ (initializes to 000h code)
Output drive	Each D/A OUT	±15 mA
Slew rate		0.8 V/µs typ

Note 5: Maximum throughput scanning from PC memory is machine dependent.

Table 7. Analog output accuracy

Range	Accuracy (±LSB)
0 V to 4.096 V	4.0 typ, 45.0 max

Table 8. Analog output accuracy components

Range	% of FSR (±)	Gain Error at FS (±mV)	Offset (±mV) (Note 6)	Accuracy at FS (±mV)
0 V to 4.096 V	0.1 typ, 0.9 max	4.0 typ, 36.0 max	1.0 typ, 9.0 max	4.0 typ, 45.0 max

Note 6: Zero-scale offsets may result in a fixed zero-scale error producing a "dead-band" digital input code region.. In this case, changes in digital input code at values less than 0x040 may not produce a corresponding change in the output voltage. The USB-1408FS offset error is tested and specified at code 0x040.

Digital I/O

Table 9. Digital I/O specifications

Parameter	Specification
Digital type	CMOS
Number of I/O	16 (Port A0 through A7, Port B0 through B7)
Configuration	2 banks of 8
Pull-up/pull-down configuration	All pins pulled up to 5V via 47 kΩ resistors (default). Hardware with p/n 193331x (where x is the revision letter) may be changed to pull-down using an internal jumper. Other hardware versions can be configured for pull-down at the factory.
Input high voltage threshold	2.0 V min
Input high voltage limit	5.5 V absolute max
Input low voltage threshold	0.8 V max
Input low voltage limit	–0.5 V absolute min 0 V recommended min
Output high voltage (IOH = –6.0 mA)	3.84 V min
Output low voltage (IOL = 6.0 mA)	0.33 V max
Power on and reset state	Input

External trigger

Table 10. External digital trigger specifications

Parameter	Conditions	Specification
Trigger source	External, digital	TRIG_IN
Trigger mode	Software-selectable	Edge sensitive: user configurable for CMOS compatible rising or falling edge
Trigger latency		10 µs max
Trigger pulse width		1 µs min
Input type		Schmitt trigger, 47 kΩ pull-down to ground
Schmitt trigger hysteresis		1.01 V typ 0.6 V min 1.5 V max
Input high voltage threshold		2.43 V typ 1.9 V min 3.1V max
Input high voltage limit		5.5 V absolute max
Input low voltage threshold		1.42 V typ 1.0 V min 2.0 V max
Input low voltage limit		-0.5 V absolute min 0 V recommended min

External clock input/output

Table 11. External clock I/O specifications

Parameter	Conditions	Specification
Pin name		SYNC
Pin type		Bidirectional
Direction (software-selectable)	Output	Outputs internal A/D pacer clock. Active on rising edge.
	Input (default)	Receives A/D pacer clock from external source. Active on rising edge.
Input clock rate		48 kHz, maximum
Clock pulse width	Input mode	1 µs min
	Output mode	5 µs min
Input type		Schmitt trigger, 47 kΩ pull-down to ground
Schmitt trigger hysteresis		1.01 V typ 0.6 V min 1.5 V max
Input high voltage threshold		2.43 V typ 1.9 V min 3.1V max
Input high voltage limit		5.5 V absolute max
Input low voltage threshold		1.42 V typ 1.0 V min 2.0 V max
Input low voltage limit		-0.5 V absolute min 0 V recommended min
Output high voltage		4.4 V min (IOH = –50 µA) 3.80 V min (IOH = –8 mA)
Output low voltage		0.1 V max (IOL = 50 µA) 0.44 V max (IOL = 8 mA)

Counter section

Table 12. Counter specifications

Parameter	Specification
Pin name	CTR
Counter type	Event counter
Number of channels	1
Input type	Schmitt trigger, 47 kΩ pull-down to ground
Input source	*CTR screw terminal*
Resolution	32 bits
Maximum input frequency	1 MHz
High pulse width	*500 ns min*
Low pulse width	*500 ns min*
Schmitt trigger hysteresis	1.01 V typ 0.6 V min 1.5 V max
Input high voltage threshold	2.43 V typ 1.9 V min 3.1V max
Input high voltage limit	5.5 V absolute max
Input low voltage threshold	1.42 V typ 1.0 V min 2.0 V max
Input low voltage limit	-0.5 V absolute min 0 V recommended min

Non-volatile memory

Table 13. Non-volatile memory specifications

Parameter	Specification		
EEPROM	1,024 bytes		
EEPROM Configuration	**Address Range**	**Access**	**Description**
	0x000 to 0x1FF	Read/write	512 bytes user area
	0x200 to 0x3FF	Read/write with unlock	512 bytes calibration data

Microcontroller

Table 14. Microcontroller specifications

Parameter	Specification
Type	*High performance 16-bit RISC microcontroller*

Power

Table 15. Power specifications

Parameter	Conditions	Specification
Supply current (Note 7)		80 mA
+5V USB power available (Note 8)	Connected to self-powered hub Connected to externally-powered root port hub	4.5 V min, 5.25 V max
	Connected to bus-powered hub	4.1 V min, 5.25 V max
Output current (Note 9)	Connected to self-powered hub Connected to externally-powered root port hub	420 mA max
	Connected to bus-powered hub	20 mA max

Note 7: This is the total current requirement for the USB-1408FS which includes up to 10 mA for the status LED.

Note 8: *Self-powered hub* refers to a USB hub with an external power supply. Self-powered hubs allow a connected USB device to draw up to 500 mA.

Root port hubs reside in the PC USB host controller. The USB port(s) on your PC are root port hubs. All externally powered root port hubs (desktop PCs) provide up to 500 mA of current for a USB device. Battery-powered root port hubs provide 100 mA or 500 mA, depending upon the manufacturer. A laptop PC that is not connected to an external power adapter is an example of a battery-powered root port hub.

Bus powered hubs receive power from a self-powered or root port hub. In this case the maximum current available from the USB +5 V is 100 mA. The minimum USB +5 V voltage level can be as low as 4.1 V.

Note 9: Output current refers to the total amount of current that can be sourced from the USB +5 V, analog outputs and digital outputs.

General

Table 16. General specifications

Parameter	Specification
Device type	USB 2.0 full speed
Device compatibility	USB 1.1, USB 2.0

Environmental

Table 17. Environmental specifications

Parameter	Specification
Operating temperature range	0 °C to 70 °C
Storage temperature range	–40 °C to 70 °C
Humidity	0% to 90% non-condensing

Mechanical

Table 18. Mechanical specifications

Parameter	Specification
Dimensions	79 × 82 × 27 mm (3.10 × 3.20 × 1.05 in.)
USB cable length	3 m (9.84 ft) max
User connection length	3 m (9.84 ft) max

Screw terminal connector

Table 19. Screw terminal specifications

Parameter	Specification
Connector type	Screw terminal
Wire gauge range	16 AWG to 30 AWG

Differential mode pinout

Table 20. 4-channel differential mode pinout

Pin	Signal Name	Pin	Signal Name
1	CH0 IN HI	21	Port A0
2	CH0 IN LO	22	Port A1
3	AGND	23	Port A2
4	CH1 IN HI	24	Port A3
5	CH1 IN LO	25	Port A4
6	AGND	26	Port A5
7	CH2 IN HI	27	Port A6
8	CH2 IN LO	28	Port A7
9	AGND	29	GND
10	CH3 IN HI	30	PC +5V
11	CH3 IN LO	31	GND
12	AGND	32	Port B0
13	D/A OUT 0	33	Port B1
14	D/A OUT 1	34	Port B2
15	AGND	35	Port B3
16	+2.5VREF	36	Port B4
17	GND	37	Port B5
18	TRIG_IN	38	Port B6
19	SYNC	39	Port B7
20	CTR	40	GND

Single-ended mode pinout

Table 21. 8-channel single-ended mode pinout

Pin	Signal Name	Pin	Signal Name
1	CH0 IN	21	Port A0
2	CH1 IN	22	Port A1
3	AGND	23	Port A2
4	CH2 IN	24	Port A3
5	CH3 IN	25	Port A4
6	AGND	26	Port A5
7	CH4 IN	27	Port A6
8	CH5 IN	28	Port A7
9	AGND	29	GND
10	CH6 IN	30	PC +5V
11	CH7 IN	31	GND
12	AGND	32	Port B0
13	D/A OUT 0	33	Port B1
14	D/A OUT 1	34	Port B2
15	AGND	35	Port B3
16	+2.5VREF	36	Port B4
17	GND	37	Port B5
18	TRIG_IN	38	Port B6
19	SYNC	39	Port B7
20	CTR	40	GND

CE Declaration of Conformity

Manufacturer: Measurement Computing Corporation
Address: 10 Commerce Way
Suite 1008
Norton, MA 02766
USA

Category: Electrical equipment for measurement, control and laboratory use.

Measurement Computing Corporation declares under sole responsibility that the product

USB-1408FS

to which this declaration relates is in conformity with the relevant provisions of the following standards or other documents:

EC EMC Directive 2004/108/EC: Electromagnetic Compatibility, EN 61326-1:2006, (IEC 61326-1:2005)

Emissions:

- EN 55011 (1990)/CISPR 11 Radiated emissions: Group 1, Class A
- EN 55011 (1990)/CISPR 11 Conducted emissions: Group 1, Class A

Immunity: EN61326-1:2006, (IEC 61326-1:2005) Table 3 Immunity requirements for equipment used in controlled EM environments.

- IEC 61000-4-2 (2001): Electrostatic Discharge immunity.
- IEC 61000-4-3 (2002): Radiated Electromagnetic Field immunity.

To maintain the safety, emission, and immunity standards of this declaration, the following conditions must be met.

- The host computer, peripheral equipment, power sources, and expansion hardware must be CE compliant.
- Equipment must be operated in a controlled electromagnetic environment as defined by Standards EN 61326-1:2006, or IEC 61326-1:2005.
- Shielded wires must be used for all I/Os and must be less than 3 meters (9.75 feet) in length.
- The host computer must be properly grounded.
- The host computer must be USB 2.0 compliant.
- A protective ESD wrist strap should be used when connecting or disconnecting leads from screw terminal blocks.

Note: Data acquisition equipment may exhibit noise or increased offsets when exposed to high RF fields (>1V/m) or transients.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in February, 2006. Test records are outlined in Chomerics Test Report #EMI4445.06. Further testing was conducted by Chomerics Test Services, Woburn, MA. 01801, USA in November, 2008. Test records are outlined in Chomerics Test report #EMI5193.08.

We hereby declare that the equipment specified conforms to the above Directives and Standards.

Carl Haapaoja, Director of Quality Assurance

Measurement Computing Corporation
10 Commerce Way
Suite 1008
Norton, Massachusetts 02766
(508) 946-5100
Fax: (508) 946-9500
E-mail: info@mccdaq.com
www.mccdaq.com